Annex E
Aircraft Wire Systems Defect Fabrication Procedures

This annex provides a description of each of the procedures used to fabricate the wire defects used in the test bed. This includes defect type, tools used, step-by-step text and illustrative photographs, and photographs of the resulting defect.

Aircraft Wire System Test-Bed Defects Fabrication

Harnesses used in the test bed enclosure will have one or more defects of the type described below. The defect descriptor found in Table 2 of the report corresponds to the specifications for each defect fabrication. The goal of these procedures was to make the fabrication process repeatable with little complexity.

DT-1: Insulation Abrasion

Tools: Dremel #380-6, Router Bit, Safety Glasses
Specification: Location on Wire; Radial Percent of Insulation Removed; Linear and Angular Extent

The following procedure describes the methods and tools used to fabricate abrasions into the wire used in the Test-Bed. Abrasions are made with a custom-milling fixture shown in Figure DT1-1 (Dremel Moto-Tool Model # 380-6, Variable Speed).

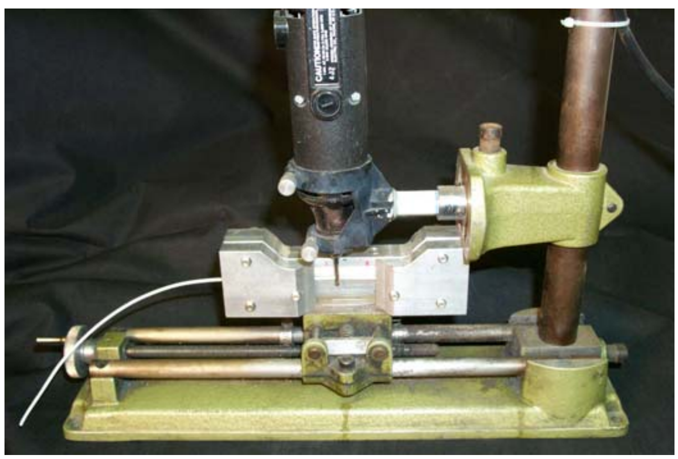


Figure DT1–1. Dremel Tool Mounted in Custom Mill

To achieve reproducibility, the same router bit shall be used in all abrasions put into the Test-Bed wiring (Dremel part number 9903, tungsten carbide bit, shown in Figure DT1-2). The Dremel Tool # 380-6 shall be operated at 28,000 RPM for all work. Because of varying dimensions in the insulations of different wire types used in the test bed, there will be differing amounts of feed used on each wire clamped in the mill. Figure DT1-2 shows two views of a wire clamped in the Dremel Mill.

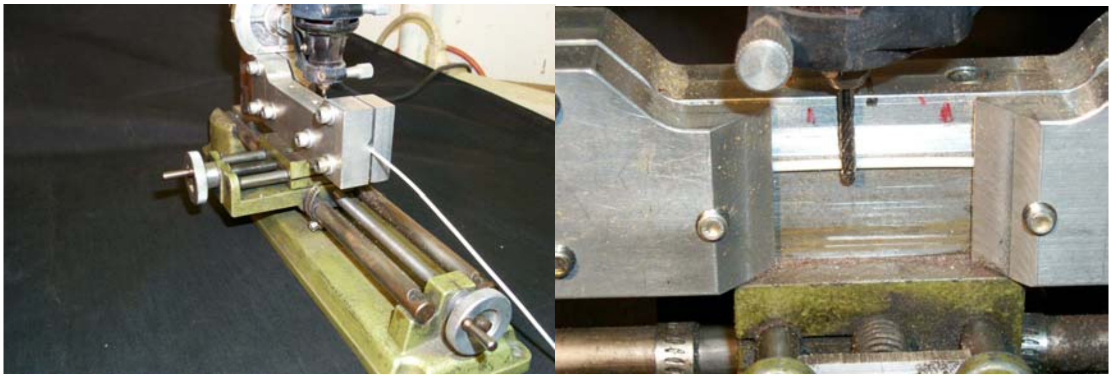


Figure DT1-2. Showing Two Views of a Wire Clamped in Abrasion Test Fixture

After the wire is clamped into the vise on the mill, the carbide cutter must then be located to within a few mils of the wire insulation. The technique of using a piece of paper (approximately 2 mils thick) between the bit and the insulation will be used. With one hand cranking the X-axis dial and the other hand sliding a small piece of paper between the bit and insulation, move the vise until the paper is just able to be removed from between the bit and wire without tearing (tool is not energized at this time). This technique is shown in Figure DT1-3.

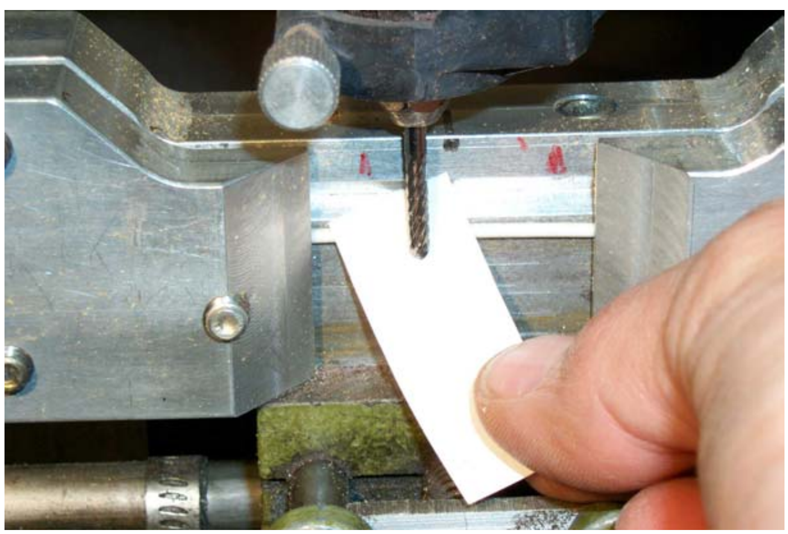


Figure DT1-3. Wire-to-Bit Spacing Adjustment Using Small Piece of Paper

Before energizing the tool, make sure that the Y-axis feed dial is fully counter-clockwise and travel is completed by the stop. Because of the rotation of the tool, all feeds for the lateral abrasions shall be done with one pass. Energize the Dremel and crank in on the X-axis dial to the desired depth. Each cut will be specific to the type of wire and type of cut required. The X-axis dial is marked with .0005” increments. Adjust the Y-axis stop to the specified abrasion length. Crank the Y-axis dial clockwise until the stop is encountered. Turn off Dremel tool and remove the wire from the vise. Two examples of wire abrasions are shown in Figures DT1-4 and –5.

Figure DT1-4. Partial Wire Insulation Abrasion

Figure DT1-5. Full Wire Insulation Abrasion Exposing Conductor

DT-2: Insulation Breach

Tools: Stanley 10-099 knife, Stanley 11-921 blade, 25 blade feeler gauge set, measurement calibers, Fixture #1, Allen Screw Driver, Safety Glasses
Specification: Location on Wire; 360° Insulation Removed; Linear Extent

Figure DT2-1. Stanley Knife and Blade

Figure DT2-2. Feeler Gauge Set

The following procedure describes the methods and tools used to fabricate three different incisions into the wire used in the test bed. The three different incisions will be referred to as the straight cut, the lateral breach, and partial insulation removal.

Straight Cut and Circumferential Lateral Breach

Measure the overall wire insulation diameter, splice off the insulation (at the end of a sample wire), and measure the conductor diameter. Subtract the conductor diameter from the insulation diameter. Divide this difference by two, resulting in the insulation radial thickness. Stack the proper amount of feeler gauges on a flat surface to equal the conductor diameter and radius of insulation thickness. Figure DT2-3 illustrates this geometry. Figure DT2-4 shows the cutting fixture (#1) and feeler gauges.

Figure DT2-3. Drawing of Breach Defect Cutting Geometry

Figure DT2-4. Breach Defect Cutting Fixture and Feeler-Gauges

Secure feeler gauges to work surface and lay test wire parallel to the edge of the gauges. Using the Stanley knife press down on the wire insulation until the blade contacts with the top surface of the feeler gauge stack and not going below the top surface of gauges. Figures DT2-5 and DT2-6 show the wire positioned in the cutting fixture and the resulting straight cut. Rotate the wire 90 to 180° and cut again. Repeat the process until a complete 360° circumferential cut through the insulation is achieved. To fabricate a circumferential lateral breach, produce two similar cuts at the desire separation length (e.g., 1 inch away). Make a lateral cut along the separation length, down to the feeler gauge, separate insulation halves, and remove. Figure DT2-7 shows a circumferential lateral breach.

Figure DT2-5. Wire Positioned in Cutting Fixture

Figure DT2-6. Straight Cut Result

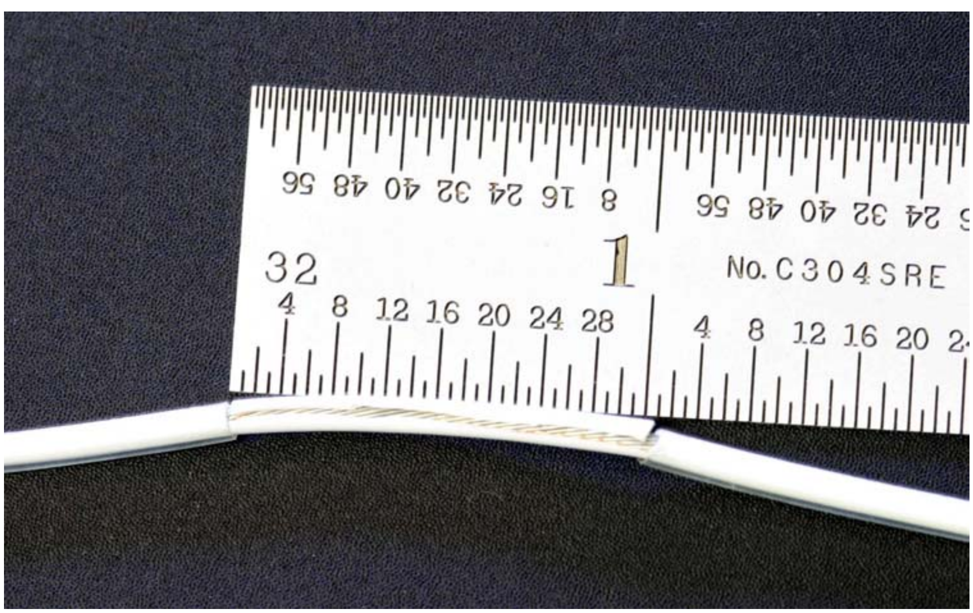
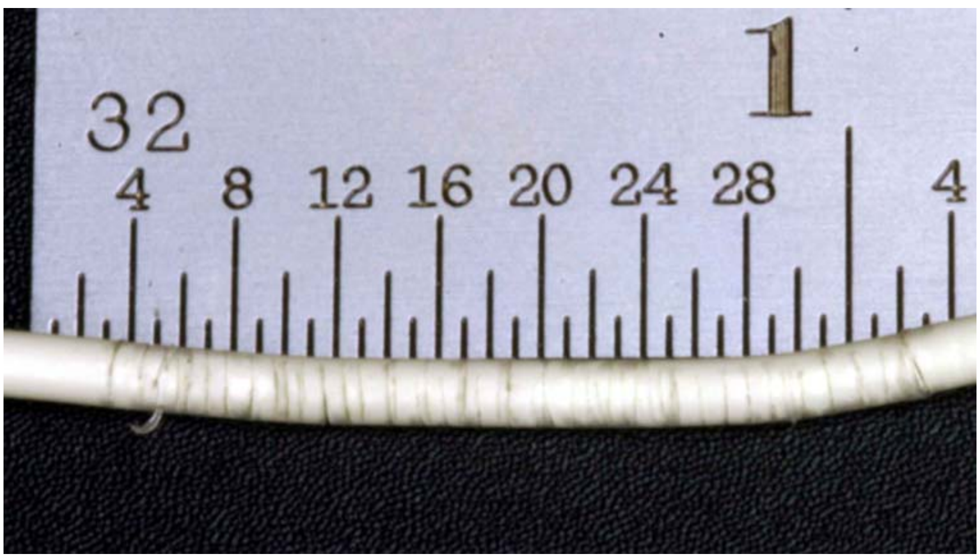


Figure DT2-7. Circumferential Lateral Breach

DT-3: Cracked Insulation

Tools: Same as specified in DT-2
Specification: Linear Extent; Percent into Insulation Radius; Density (cuts per inch)

The following procedure will describe a method used to fabricate cracked insulation on wires placed in the test bed. The method introduces a specified number of cracks per inch of wire (density) using the straight knife cut procedure described above in DT-2: Insulation Breach. Determine the proper height of feeler gauge stack by using the measuring steps described in DT2. For cuts that do not go all of the way to the conductor, calculate the additional amount of feeler gauge height by multiplying the percent of remaining insulation desired by the insulation thickness. Figure DT2-1 shows the setup for producing a single cut into the insulation. Figure DT3-1 shows the resulting defect after using this procedure.



DT3-1. Simulated Cracked Insulation Defect from Straight Knife Cuts

DT-4: Conductor Strand Breaks

Tools: Same as tools used in DT-2
Specification: Location on Wire; Percent of Conductor Strands Severed

The following procedure will describe the method used to fabricate wire conductor partial strand breakage. Using the procedure described for mounting the wire into the cutting fixture described in section DT-2, secure the specimen wire and feeler gauges on the cutting fixture. Using the Stanley knife, cut into insulation until side of blade is flush with feeler gauges. Make a 360^0 cut sufficient to expose conductor strands. Remove the wire from the fixture and using the knife select the particular strand. Using a smaller knife, sever the strand. Repeat the procedure until the specified number of strands is severed. After cutting the individual strands, bend each strand backwards (180°), so no contact is made with other strand cuts. Apply heat shrink tubing over defect to hold strands in place and to isolate severed strands. Figure DT4 – 1 shows the wire mounted in the fixture and strand selection and Figure DT4-2 shows the strand folded back.

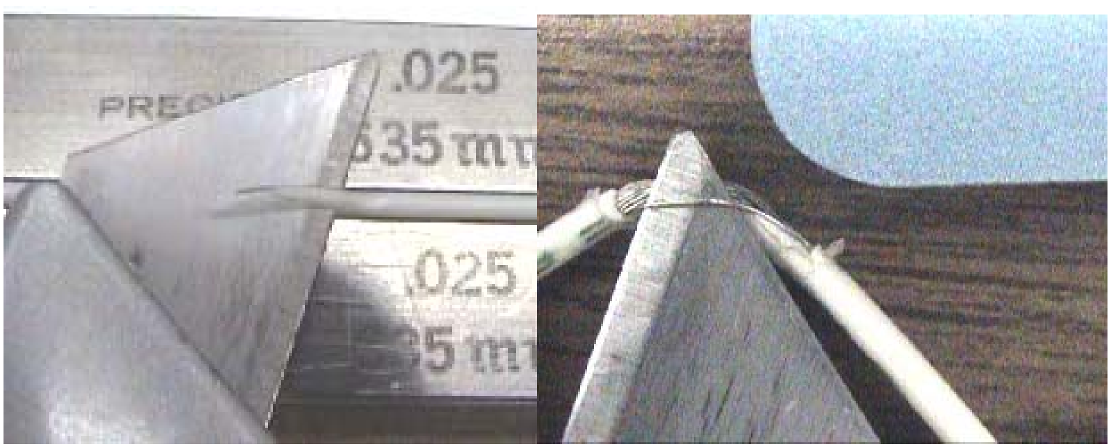


Figure DT4-1. Two Steps Required for a Partial Conductor Strand Cut

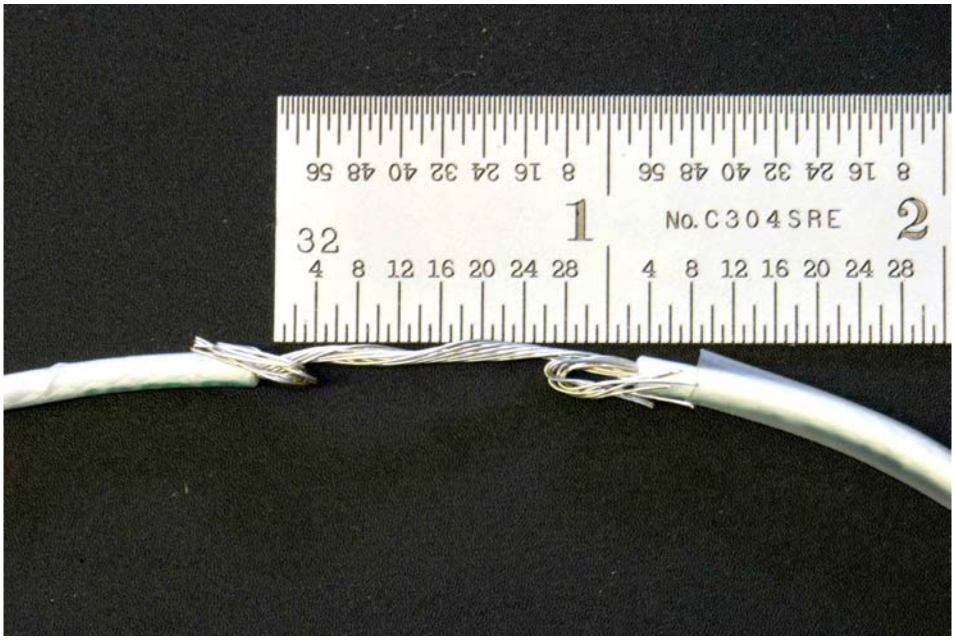
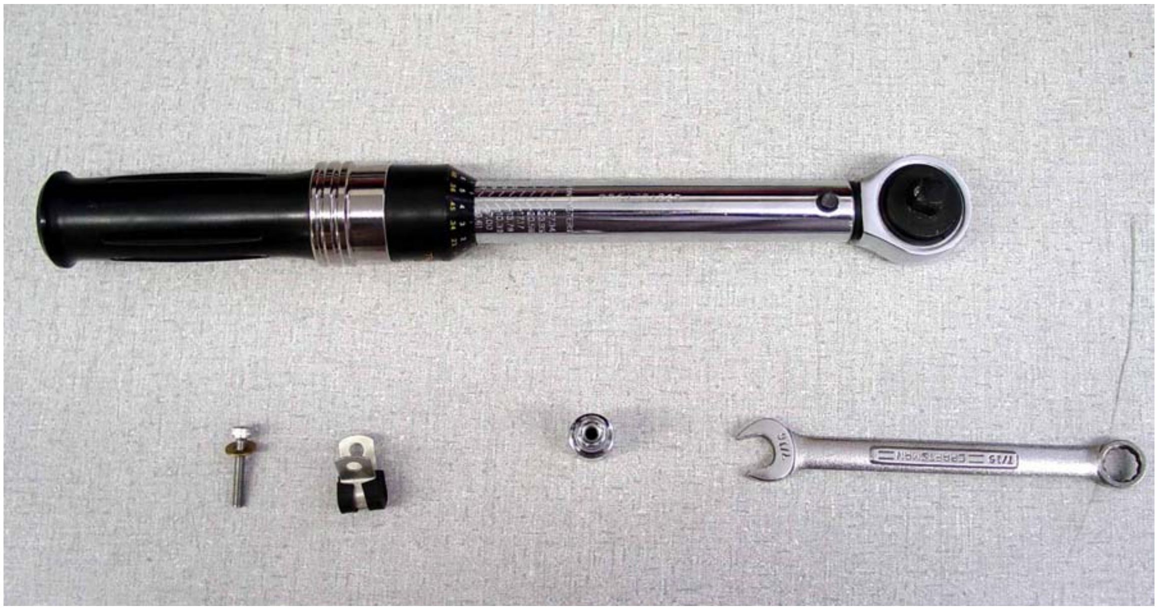


Figure DT4-2. Result of Conductor Strand Cut and Fold-Back

DT-5: Over-Pressured Clamps

Tools: Harness Clamp and Nut and Bolt, Socket and Torque Wrench, Ratchet, Safety Glasses
Specification: Location; Clamp Size, Torque Value

The following procedure describes the two methods used to over-pressure harness clamps. Figure DT5-1 shows the tools that are needed to produce an over-pressured clamp. Using a clamp that is undersized, remove any cushion/padding from the clamp and secure the clamp around the harness at the specified location. The location may correspond to a ribbed structure element of the simulated aircraft fuselage segment location within the enclosure. Using the socket wrench and an appropriately sized ratchet, compress the clamp around harness to a normal (~10 inch-lb) degree of tightness. Next use the torque wrench to the specified value of clamp tightness or compression (units of inch-lb). Another variation of this defect type is to allow one to three wires to be pinched by the hardware section of clamp. Both of these over-pressured clamp defects are shown in Figure DT5-2.



DT5-1. Tools Needed for DT5

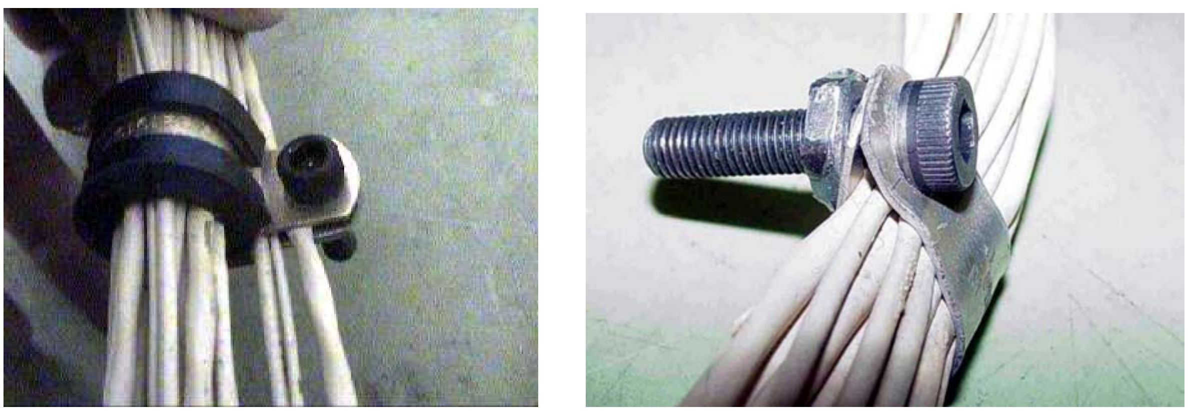


Figure DT5-2. Two Types of Over-Pressured Clamp Defects

Another clamp related defect is due to worn-away clamp insulation and the action (vibration) of the exposed metallic portion of the clamp rubbing against the wire insulation. This clamp-related defect type can be fabricated by using the procedure described in DT-1 to chafe-off insulation from one or more wires, and a clamp without an insulation barrier is placed over the chafed wire(s). However, this defect type is similar electrically to a short, or partial short, for a particular wire and is addressed in defect type DT-10 (short wire defect).

DT-6: Bend Radius

Tools: Plastic Tie-Bands, Tie-Band Tool
Specification: Location; Bend Diameter

The following procedure will describe the method used to introduce excessive bending radius of harnesses. Ensure that the specimen harness has sufficient length so that when installed into the test bed the connectors are capable of spanning the enclosure length. Bend the harness to a specified radius in multiples of harness diameter. Apply tie band. Repeat the process to orient the harness on the intended path within the enclosure. Figure DT6-1 shows a zero bend-radius defect with two tie bands securing the bends in place and a wire with harness diameter separation of about two diameters.

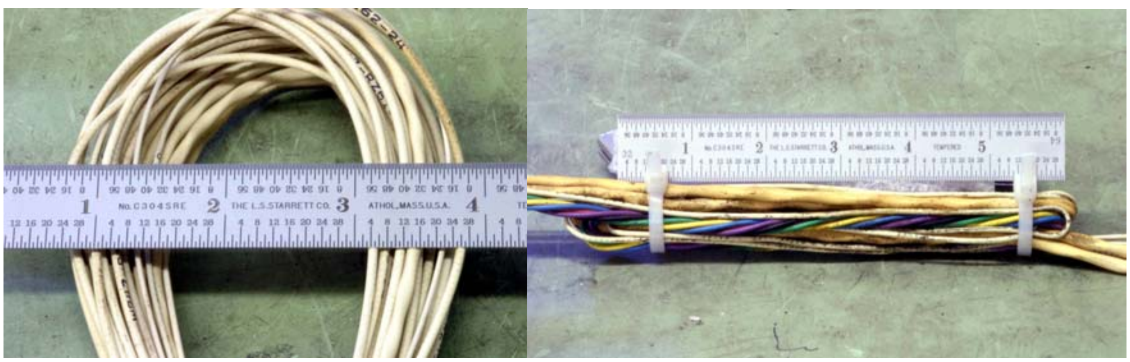
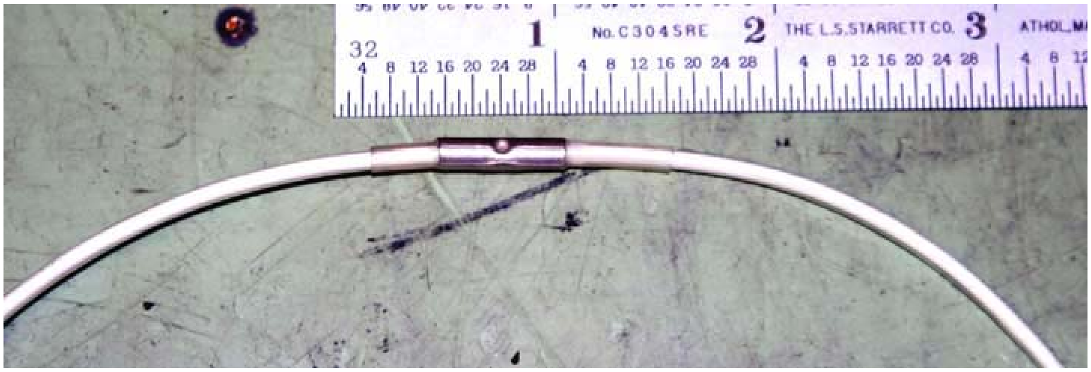


Figure DT6-1. Illustration of Harness Diameter Separation and Applied Tie-Band

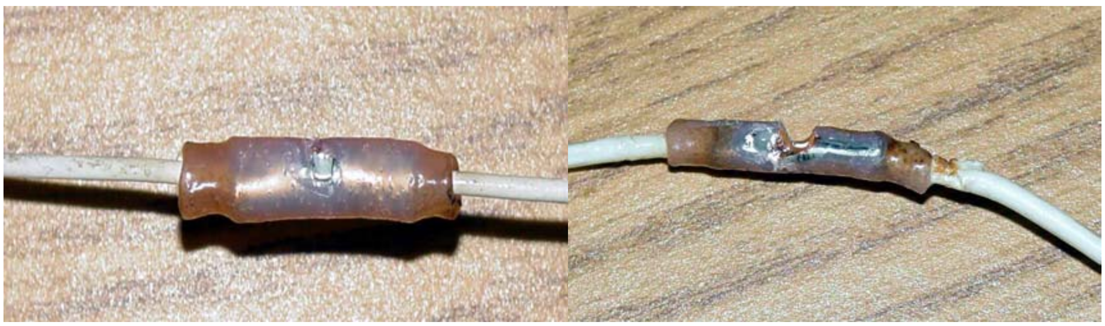
DT-7: Faulty Splice

Tools: Butt Splice Joint, Crimp Tool, Heat Shrink Tubing, Heat Gun, Electrical Tape
Specification: Location on Wire; Severity Type Details (see method description below)

The following procedure will describe three methods used to introduce faulted wire splices. The first method (type I) inserts each end of the wire to be joined into a butt joint but *with no* crimping and *with* heat applied to heat-shrink tubing that is placed about it. This defect is shown in Figure DT7-1. The second method (type II) is a crimped but exposed splice. This defect is shown in the left photograph of Figure DT7-2. The third method (type III) is a crimped splice but excessively over heated. This defect is shown in the right photograph of Figure DT7-2. This type three defect utilizes the charred insulation procedure, exposed for ~ 1 to 1.5 minutes, described in section DT-8 below.



DT7-1. Example of Type I Un-Crimped but Heated Faulted Splice



DT7-2. Type II (Left) and Type III (Right) Faulted Splices

DT-8: Charred Insulation

Tools: Heat Gun Wire-Mounting Fixture, Adjustable Wrench, Allen Driver, Thermocouple, Digital Thermometer, Safety Glasses, Thermal Protection Gloves
Specification: Location; Linear Extent; Exposure Duration

The following procedure describes the method used to fabricate charred wire specimens. Adjust the height of the heat gun wire-mounting fixture so that the wire holder is approximately 1-inch above the heat gun nozzle. The fixture is shown in Figure DT8-1. Turn on the heat gun until the thermometer indicates 500°F. Turn off the heat gun, and quickly place wire specimen on fixture. Turn on the heat gun and expose wire for specified duration. Record exposure time and indicated temperature. Do not allow heat gun to cool down until all desired wires are burned. Figure DT8-2 shows the resulting defects of varying burn severities.

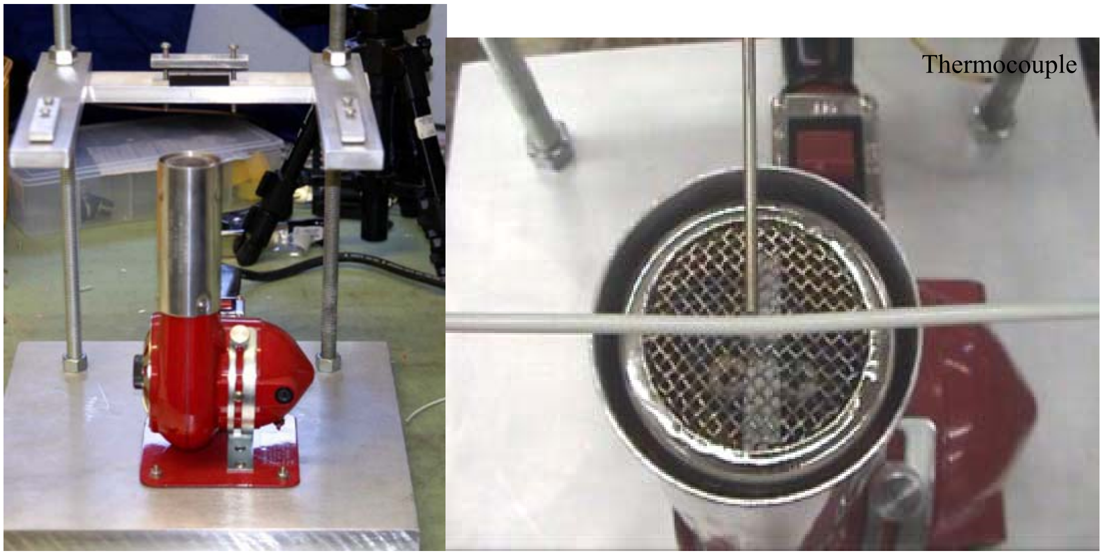
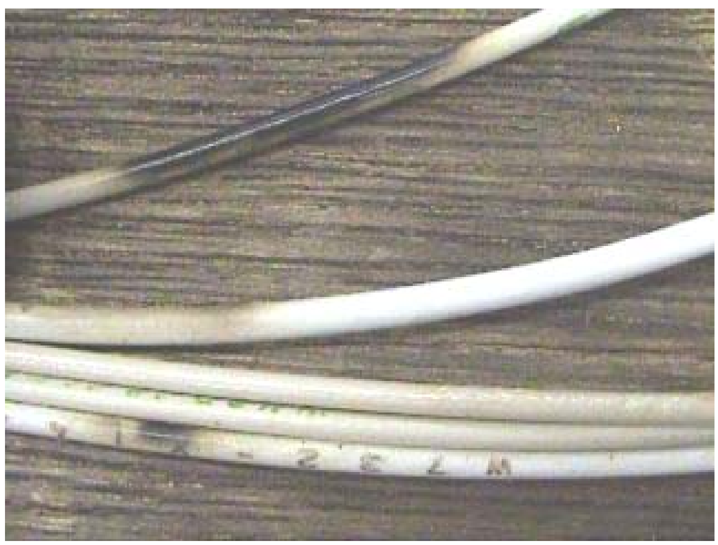


Figure DT8-1. Heat Gun and Wire Mounting Fixture with Close-up View of Wire Positioned Over Heat Gun Nozzle



DT8-2. Resulting Severities of Burnt Wires

DT-9: Opened Conductor

Tools: Wire Cutter, Solder Station, Safety Glasses
Specification: Location; With Contact; Without Contact

The following procedure describes the method used to introduce unintended open circuited conditions in wire specimens. Select assembled wire harness and location where the open circuit defect is to be placed. Select particular wire that is to be electrically opened and use cutters to sever the wire. If no contact is specified cut off ¼-inch segment of the wire and cover with electrical tape. If contact is to be maintained between each side of the previously uncut wire, solder together the desired number of strands that correspond to the percentage of contact to be maintained and cover with electrical tape. For example, solder together half of the strands of each end of wire for fifty percent contact. Figure DT9-1 shows the tools needed to do the procedure. Figure DT9-2 shows the soldering together of wire strands and the resulting defects.

Figure DT9-1. Tools Needed for Opened Wire Conductor Defect

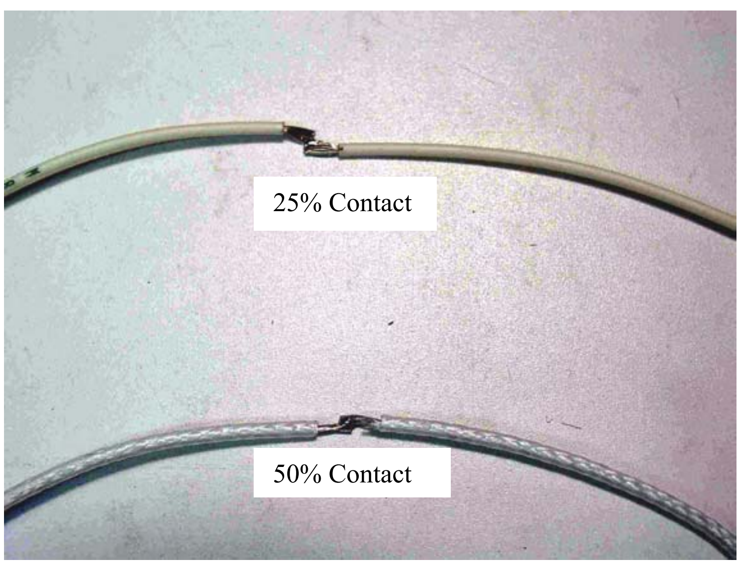
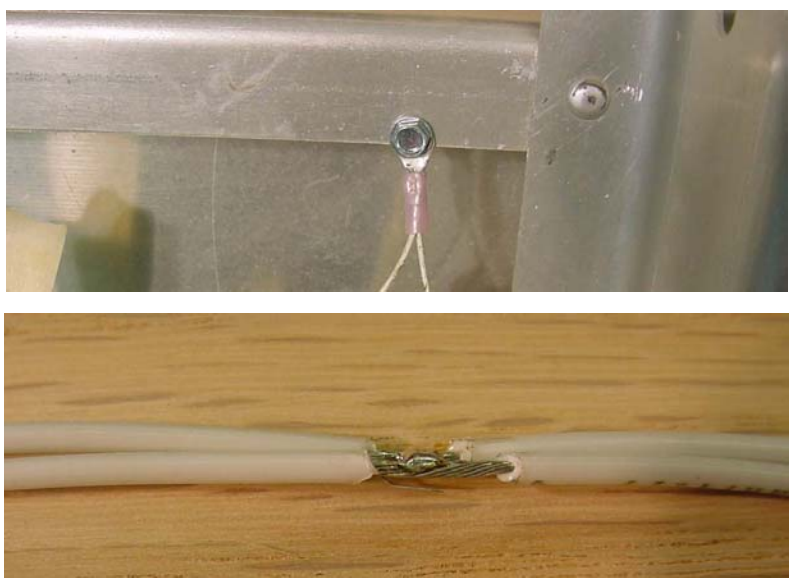


Figure DT9-2. 50 and 25 Percent of Varying Degrees of Contact

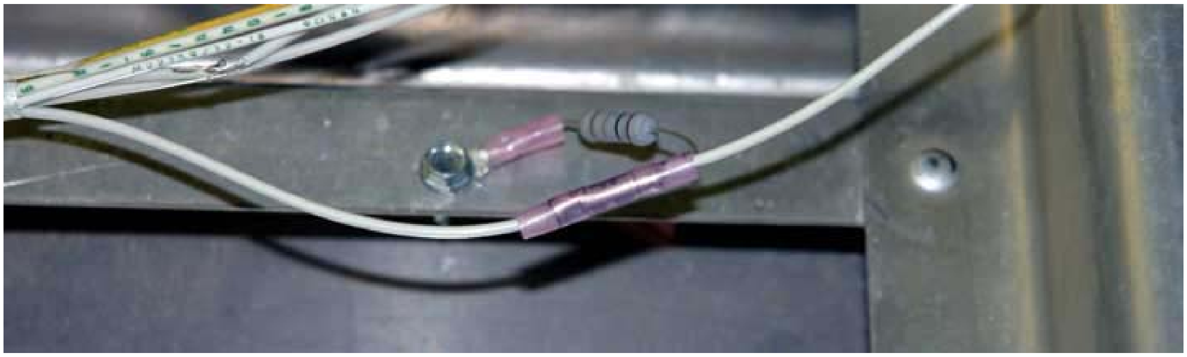
DT-10: Shorted Conductor

Tools: Wire Cutter, O-Lug, Crimper, Solder Kit, Safety Glasses, Sheet Metal Screw, Power Screw Driver, Safety Glasses, Resistors
Specification: Location; Short Path (Differential or Common Mode)

The following procedure will describe two methods used to introduce unintended short-circuited conditions in wire specimens. Select wire specimen and short location. The first method is a wire shorted to the enclosure frame (common mode). Cut wire and crimp on O-lug. Use a sheet metal screw and power drive to attach lug to enclosure frame. The second method uses the lateral breach procedure provided in section DT-2 to remove a segment of insulation of two adjacent wires and then a solder joint to short the two wires together (differential mode). Figure DT10-1 shows both wire short types. The severity of both types of shorts can be varied by soldering resistors of varying ohmic values between the ends of the short. This is shown in Figure DT10-2.



DT10-1. Photographs of Two Short Types



DT10-2. Resistor Used to Simulate a Partial Short